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Circular No. 787

June 1948 • Washington, D. C.

UNITED STATES DEPARTMENT OF AGRICULTURE

Cooperative Studies of Sweetpotato-Plant Production

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United States Department of Agriculture, Agricultural Research Administration, Bureau of Plant Industry, Soils, and Agricultural Engineering, in cooperation with the Agricultural Experiment Stations of Mississippi and South Carolina

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INTRODUCTION

This circular is the third in a series (*1, 2*) [2] reporting the results of an extensive, coordinated, regional research program with sweetpotatoes. The program was begun in 1939, and the cooperating agencies are the Bureau of Plant Industry, Soils, and Agricultural Engineering and seven southern State agricultural experiment stations.[3] In general, the investigations may be divided into two more or less distinct phases: (1) The development of superior table types and starch and feed types by breeding, and (2) the evaluation and improvement of cultural and storage practices. This circular presents the results of studies of the influence of certain cultural, harvest, and storage factors on the plant production of the bedded roots.

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[1] The authors are indebted to C. E. Steinbauer, physiologist, Division of Fruit and Vegetable Crops and Diseases, for assistance in planning the work and for reviewing the manuscript.

[2] Italic numbers in parentheses refer to Literature Cited, p. 17.

[3] The Agricultural Experiment Stations of Georgia, Louisiana, Mississippi, South Carolina, and Texas, the Georgia Coastal Plain Experiment Station, and the Virginia Truck Experiment Station.

NEED FOR INFORMATION ON SWEETPOTATO-PLANT PRODUCTION

In the United States the sweetpotato is a major vegetable crop. Although the species can be propagated both by seeds and by vegetative methods, varieties are always propagated by the latter methods. Seeds are used only to develop superior types and varieties through breeding. Young plants (also called sprouts, slips, or draws) and vine cuttings are used to establish both home-garden and commercial plantings. These young plants and vine cuttings always come directly or indirectly from the fleshy roots. Since large quantities of such roots are necessary for the establishment of the many home-garden and commercial plantings, knowledge of the effects of cultural and environmental factors on their plant production has much practical significance.

Although the influence of certain environmental and cultural factors during plant production by the fleshy roots in the propagating bed has been studied (*4*, *5*), little experimental information is available on the effect of environmental and cultural factors in the field or of storage conditions of the preceding season on plant production. To what extent do environmental and cultural factors during the periods of root development and of curing and storage affect subsequent sprout production in the plant bed?

Edmond (*3*) studied the influence of a short exposure of the fleshy roots to low temperature on sprout production. He subjected roots of the Unit I Porto Rico to 40° F. for 4 days, 7 days, and 14 days and found that the 7- and 14-day exposures decreased the number of plants produced per root and per bushel, increased the weight of root required to produce a unit weight of plant, and induced marked rooting of the bedded roots. However, the experiments were made at the end of the regular storage period and with one variety only. Since certain environmental, cultural, and storage conditions markedly influence the yield, grade, and storage life of the roots, it is logical to expect that these factors may influence their plant-producing capacity also. The present studies were undertaken to evaluate the influence of some of these factors on plant production.

MATERIALS AND METHODS

The studies reported herein involved the effects of three factors—namely, nitrogen supply, time of harvest, and curing and storage of roots—on the plant production of two rather distinct types of sweetpotato, Unit I Porto Rico and Triumph. The Unit I Porto Rico (herein designated "Porto Rico") is a distinct market type. The roots have copper-red skin and salmon-pink flesh and are moderately high in carotene (*1*) and starch (*2*). At present this variety is grown extensively in southeastern United States for local markets and long-distance shipment. On the other hand, the Triumph is primarily a starch and feed type. At present it is also grown in limited quantities in the vicinity of Mobile Bay, Ala., for long-distance shipment and in the vicinity of Laurel, Miss., for vacuum canning. The roots have light-tan skin and creamy-white flesh, contain practically no carotene, and are relatively high in starch (*2*).

In these studies the cooperating agencies were the Mississippi and the South Carolina Agricultural Experiment Stations and the Bureau of Plant Industry, Soils, and Agricultural Engineering. In Mississippi all phases of the work were conducted at State College. In South Carolina the roots were grown and stored at the Edisto Experiment Station at Blackville and the plants were grown at the main station at Clemson. The Bureau of Plant Industry, Soils, and Agricultural Engineering participated in the planning, financing, and reporting of the work. The work was begun in the spring of 1941 and carried on continuously in Mississippi through the spring of 1944 and in South Carolina through the spring of 1943.

FIELD PRODUCTION OF ROOTS

The 3 variables under study involved 3 harvest dates, 2 nitrogen levels, and 4 curing and storage treatments. In Mississippi for both varieties and for the 3 years a 2-way split block, 3 by 4 design, was used in the field. The 12 subblocks were given over to the 3 harvest dates, and the 2 nitrogen levels were planted within each subblock. In this case medium-high ridges (9 to 10 inches) were maintained.

In South Carolina the 3 harvest dates and 2 nitrogen levels for the Porto Rico variety were part of another project which also included 3 heights of ridge. A 3-way split block, 4 by 4 design, was used. Thus, for any 1 year there were 16 subblocks and 48 sub-subblocks. The plots for the time-of-harvest treatments were planted in the subblocks, those for the height-of-ridge treatments in the sub-subblocks, and those for the nitrogen treatments within each sub-subblock.

Roots for these studies were obtained from rows maintained at the medium-high ridge (9 to 10 inches). For the Triumph variety, a two-way split block, 2 by 4 design, was used. The four subblocks were divided lengthwise into two equal parts with the low nitrogen level in one half and the high nitrogen level in the other half; and the harvest treatments were randomized within each sub-subblock. All plots were maintained at the medium-high ridge (9 to 10 inches) and were adjacent to those given over to the Porto Rico.

At both places, single guard rows were planted between adjacent nitrogen plots and a single plot consisted of two adjacent rows, 50 feet long and 4 feet apart.

In general, the methods of field culture recommended for each locality were followed. Because of differences in soil and climate these methods necessarily varied with the location, and the cultural operations necessarily varied slightly from year to year at the same location. In the interest of brevity and clarity, the salient features under which the plants were grown at the cooperating stations are presented in table 1.

STORAGE TREATMENTS

The curing and storage treatments, an important phase of the investigations, were as follows: (1) Roots not artificially cured, stored in a nonheated building; (2) roots not artificially cured, stored under recommended conditions of temperature and humidity; (3) roots artificially cured, stored in a nonheated building; and (4) roots artificially cured,

TABLE 1.—*Environmental and cultural conditions under which plant production of sweetpotato roots was studied*

State and season	Field production of roots						
	Soil type	Nitrogen per acre		Planting date	Harvest date[1]		
		High	Low		Early	Medium	Late
Mississippi:		*Pounds*	*Pounds*				
1941–42	Ocklocknee loam.	80	0	May 13	Oct. 13	Nov. 8	Dec. 1
1942–43	do	80	0	May 14	Sept. 17	Oct. 19	Nov. 14
1943–44	do	100	20	May 10	Sept. 10	Oct. 23	Nov. 15
South Carolina:							
1941–42	Norfolk sandy loam.	40	10	May 2	Sept. 3	Oct. 10	Oct. 31
1942–43	do	40	10	Apr. 30	Sept. 2	Oct. 12	do

State and season	Bed production of plants				
	Bedding medium	Date roots taken from storage	Date roots bedded	Period from bedding to pulling first plants	Period of plant production
Mississippi:				*Days*	*Days*
1941–42	River-bed sand	Apr. 3	Apr. 3	24	21
1942–43	do	Mar. 29	Mar. 29	35	29
1943–44	do	Mar. 30	Mar. 30	39	29
South Carolina:					
1941–42	Mixture of clay loam and river-bed sand.	Apr. 19	Apr. 21–24	21	18
1942–43	do	Apr. 8	Apr. 9–10	21	14

[1] No frost occurred before any harvest in the South Carolina studies.

stored under recommended conditions of temperature and humidity. In these treatments the principal environmental factors were temperature and humidity. In treatment 1 the temperature and humidity fluctuated with those of the outside air. However, in treatment 4 the temperature was maintained at 80° to 85° F. during the short curing period and at 50° to 55° during the storage period with a moderately high relative humidity for both periods. The curing period extended for 5 days immediately after the roots were harvested, and the storage period began at the end of the curing period and ended during the last week of March or the first week of April—the usual time of taking sweetpotatoes out of storage for bedding operations.

The type of curing and storage room differed at the two locations. In Mississippi the artificial curing and storage rooms consisted of two Masonite nonventilated, insulated boxes—one 4 by 4 by 8 feet for curing and the other 4 by 8 by 8 feet for storage. These boxes were equipped with thermostatically controlled, electric heating coils and were placed in a stove-heated, relatively old sweetpotato storage house. The nonheated storage room was in a 25-year-old 20- by 12- by 10-foot sweetpotato storage house. Since the walls of this building were in bad repair, little insulating effect was obtained and temperatures in the room fluctuated with those of the outside air. However, whenever temperatures approached 32° F., artificial heat was supplied to avoid freezing injury to the storage roots. To maintain a moderately high humidity, shallow pans of water were kept on the floor in each room.

In South Carolina the artificial curing and storage room was one of seven 1,000-bushel rooms in a relatively new, wood-constructed sweetpotato storage house. This room was equipped with a No. 19 lead-covered, thermostatically controlled, soil-heating cable under the false floor. Moderately high humidity was maintained by placing large wads of cotton in pails of water. The cotton, wet by capillary action, furnished increased evaporating surface. The nonheated storage room was in the northeast corner of a comparatively new implement barn. To protect the roots from rats and mice and to permit fluctuations of temperature and humidity with those of the outside air, the floor and ceiling consisted of solid boards and the sides and door of hardware cloth on wooden framework.

Bed Production of Plants, or Sprouts

In Mississippi the plants were grown in a bench in a greenhouse in 1942 and 1943 and in a 48- by 6-foot sash-covered hotbed in 1944. In South Carolina they were grown in a 75- by 6-foot sash-covered hotbed in 1942 and 1943. The experimental design of the propagating beds varied with the location. In Mississippi a split block, 4 by 4 design, was used and the three variables were placed as follows: The varieties in the subblocks and the time-of-harvest, nitrogen, and storage treatments at random within the subblocks. In South Carolina a split split block, 4 by 2 design, was used. The variables were randomized in this lay-out as follows: The storage treatments were placed in the subblocks, the varieties in the sub-subblocks, and the nitrogen and harvest treatments within the sub-subblocks.

Methods of plant production at the two places were similar in some instances and dissimilar in others. At both locations, bottom heat was provided through the use of No. 19, lead-covered, thermostatically controlled, electric soil-heating cable and soil-heating thermostats were set to shut off the electricity at 85° F. The roots were watered immediately after they were bedded, then at intervals of 4 to 5 days until the first pulling of the plants, and immediately after each pulling until the experiments were concluded. The first plants were pulled 21 to 39 days after the roots were bedded, and pullings continued at intervals of 5 to 7 days until three or four pullings were made.

At both locations all roots were carefully handled; therefore they were practically free of bruises and scars that might have contributed to spoilage and variability in the plant bed.

In Mississippi each bedded lot consisted of 15 roots of the No. 1 and No. 2 grade; the period of soaking in a 1 to 1,000 solution of corrosive sublimate was 10 minutes; and the bedding medium was riverbed sand. In South Carolina each lot consisted of 20 roots, usually of the No. 1 and No. 2 grade; the period of soaking in a 1 to 1,000 solution of corrosive sublimate was 8 minutes; and the bedding medium was a mixture composed of equal parts of clay loam and riverbed sand. The salient features of the conditions under which the roots were bedded and the plants grown at both stations are presented in table 1.

Statistical Methods

The original data of each lot consisted of the number and weight of the roots at the time of bedding and the number and weight of the plants pulled for the plant-production period. Since 15 roots were used in Mississippi and 20 in South Carolina, comparable data were obtained by converting the figures to the number of plants produced per 56-pound bushel of roots.

The results are summarized in tables 2 and 4. The data were analyzed according to Yates' (*7*) method of analysis of split plots, and Snedecor's (*6*) tables of *F* values were used to determine the significance of the differences between treatments. Differences required for significance, as shown in the footnotes to tables 2 and 4, were calculated for the 5-percent level (odds 19 : 1).

The results of the variance analyses are shown in tables 3 and 5. These are presented in considerable detail for the benefit of technical workers, but in the interest of brevity only the salient features of the data are discussed.

The weights of plants harvested from the beds were found to conform closely to the numbers of plants, indicating satisfactory judgment in pulling only plants of comparable and desirable size. Data for weights show the same results as the plant numbers, therefore need not be shown in this circular.

RESULTS

Varietal Differences

Tables 2 to 5 show that Porto Rico produced on the average about 300 to 500 more plants per bushel of roots than did Triumph and that this over-all superiority was very highly significant. It was very consistent between years in the South Carolina tests but less so in Mississippi. Although in the latter place there was a greater difference in this superiority from year to year, these yearly variations were not great enough to destroy the significance of the generally greater plant-producing ability of Porto Rico.

The two varieties were very highly consistent in both places in their lack of response in the plant bed to nitrogen in the field the previous summer.

In Mississippi there was a significant difference in the way that curing and storage affected the sprout production of the 2 varieties. Of the 288 possible comparisons, Triumph produced the more sprouts in 76 of them. Of these, 64 involved either roots that had been stored warm without curing or those neither cured nor stored warm. Thus, Triumph seems to have its plant-producing capacity harmed relatively less by unsatisfactory conditions than does Porto Rico. Here again, however, the over-all productiveness of Porto Rico is significantly greater than that of Triumph. There was a similar trend in the South Carolina data.

At both locations the superiority of Porto Rico over Triumph in producing plants was much greater in roots harvested early than in those harvested at a medium or late date. Porto Rico roots from early harvests produced on the average 500 to 700 more plants per bushel than Triumph, whereas the late-harvested roots produced only 100 to 300 more. The variance due to variety was significantly greater than the interaction of variety with time of harvest; also the propagation value of Porto Rico is shown to be more sensitive to methods of handling or conditions of culture than is that of Triumph.

Effect of Time of Harvest

The time of harvest varied among the years and between locations (table 1). Tables 2 and 4 show that roots from early harvests generally produced 200 to 500 more sprouts per bushel than did those from medium and late harvests, respectively. The average production from early-harvested roots was significantly greater than from the medium- or the late-harvested ones at both places. In South Carolina the medium-harvested lot was significantly more productive than the late. In Mississippi there was no significant difference between the 3-year averages for the medium and late harvests.

It is particularly important to note the great superiority of the early-harvested roots over the late-harvested ones, even though the roots were stored in an unheated shed without curing. Evidently, by removing the roots from the field relatively early—a month or more before normal harvesttime in these two locations—the grower obtains roots that are superior for propagation even though they are subsequently exposed to temperatures not far different from those affecting roots remaining in the field. These data suggest that there are benefits from early harvesting for seed purposes besides the benefit of protection afforded by the properly operated storage house.

The relative over-all effects of time of harvest were remarkably consistent among years at both places, but the two varieties were affected to different degrees, as stated in the preceding section.

In South Carolina the storage conditions definitely affected the response to time of harvest, or the converse; but in the Mississippi experiments the relative effects of harvest were rather highly consistent at all storage conditions. In South Carolina the effects of late harvest were far more harmful to the noncured, nonheated storage lots than to those kept above 50° F., the late lots being little more than half as productive as the early ones. In the cured and heated lots the late harvest was about 85 percent as productive as the early. Thus proper

TABLE 2.—*Effects of time of harvest and method of handling seed stock of Porto Rico and Triumph sweetpotatoes on subsequent sprout production, Blackville, S. C., 1941–43* [1]

Storage treatments	Sprout production (plants per bushel of seed stock of indicated harvest)								
	Early harvest		Medium harvest		Late harvest		Mean of 3 harvests		Mean of 2 varieties
	Porto Rico	Triumph	Porto Rico	Triumph	Porto Rico	Triumph	Porto Rico	Triumph	
Roots noncured:	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Nonheated storage	2, 149	1, 740	1, 686	1, 468	1, 059	1, 046	1, 631	1, 418	1, 524
Heated storage	2, 233	1, 571	1, 722	1, 445	1, 732	1, 506	1, 896	1, 507	1, 701
Mean	2, 191	1, 655	1, 704	1, 456	1, 395	1, 276	1, 763	1, 462	1, 612
Roots cured:									
Nonheated storage	2, 204	1, 589	1, 886	1, 436	1, 321	1, 118	1, 804	1, 381	1, 592
Heated storage	2, 075	1, 604	1, 752	1, 360	1, 738	1, 409	1, 855	1, 458	1, 656
Mean	2, 139	1, 596	1, 819	1, 398	1, 529	1, 263	1, 829	1, 419	1, 624
Means:									
Nonheated storage	2, 176	1, 664	1, 786	1, 452	1, 190	1, 082	1, 717	1, 400	1, 558
Heated storage	2, 154	1, 587	1, 737	1, 402	1, 735	1, 457	1, 875	1, 482	1, 679
All treatments	2, 165	1, 625	1, 761	1, 427	1, 462	1, 269	1, 797	1, 441	1, 619
All treatments, 2 varieties	1, 895		1, 594		1, 365		1, 619		--------

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[1] Least significant difference between—

	5-percent level	
	Error 2 (*number*)	*Error 3* (*number*)
Single values, other than means	---	337
Means of 2 single values that are not means themselves	---	217
Means of 3 single values that are not means themselves	---	172
Means of 4 single values that are not means themselves	---	145
Means of 6 single values that are not means themselves	288	117
Means of harvests	---	102
Means of curings, of storage heats, or of varieties	203	83

Table 3.—*Analysis of variance of data contributing to table 2*

Source of variation	Degrees of freedom	Variance
Years	1	8, 814, 673**
Error $_1$	2	86, 113
Storages	3	282, 936
Storages × years	3	250, 300
Error $_2$	6	235, 218
Varieties	1	6, 065, 185**
Varieties × years	1	37, 829
Varieties × storages	3	110, 702
Varieties × storages × years	3	25, 347
Error $_3$	8	156, 223
Harvests	2	4, 513, 272**
Harvests × years	2	44, 510
Harvests × storages	6	495, 030**
Harvests × varieties	2	486, 700**
Harvests × storages × years	6	121, 841
Harvests × varieties × years	2	17, 091
Harvests × varieties × storages	6	29, 614
Nitrogens	1	28, 154
Nitrogens × years	1	1, 469
Nitrogens × storages	3	54, 899
Nitrogens × varieties	1	86, 318
Nitrogens × harvests	2	54, 472
Nitrogens × storages × years	3	46, 001
Nitrogens × varieties × years	1	42, 097
Nitrogens × varieties × storages	3	46, 423
Nitrogens × harvests × years	2	110, 399
Nitrogens × harvests × storages	6	152, 712
Nitrogens × harvests × varieties	2	10, 026
Pooled error (E_4)	80	82, 053

** Significant at levels exceeding 1-percent point.

care of the roots tends to reduce the bad effect of late harvesting, but does not eliminate it. The effects shown in table 4 for the Porto Rico variety are explained in part by the data in table 6.

Table 6 shows that, although there is a fairly good correlation between official mean temperatures before harvest and the plant-producing power of the roots of the Porto Rico variety within years, the agreement between years and between places is not good. It might be expected that the more serious consequence of late harvest in South Carolina is due to more rapid drop in temperature during the harvest season in that more northerly location. That, however, does not appear to be true in these tests. Some of the most striking differences in plant yield within years are associated with rather small temperature differences, and the converse is also evident. Thus, some factor besides temperature preceding harvest is producing very important effects within years as well as between years. There was no obvious relation between plant yield and rainfall to account for the differences between places or between years at the same place.

TABLE 4.—*Effects of nitrogen supply, time of harvest, and method of handling seed stock of Porto Rico and Triumph sweetpotatoes on subsequent sprout production, State College, Miss., 1941–44* [1]

Storage treatments	Field nitrogen level	Sprout production (plants per bushel of seed stock of indicated harvest)								
		Early harvest		Medium harvest		Late harvest		Mean of 3 harvests		Mean of 2 varieties
		Porto Rico	Triumph	Porto Rico	Triumph	Porto Rico	Triumph	Porto Rico	Triumph	
		Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Roots noncured:										
Nonheated storage	Low	1, 829	1, 341	1, 508	1, 276	1, 327	1, 191	1, 555	1, 269	1, 412
	High	1, 827	1, 198	1, 331	1, 242	1, 608	1, 600	1, 589	1, 347	1, 468
	Mean	1, 828	1, 269	1, 420	1, 259	1, 468	1, 396	1, 572	1, 308	1, 440
Heated storage	Low	2, 200	1, 210	1, 781	991	1, 704	1, 491	1, 895	1, 230	1, 563
	High	2, 047	1, 231	1, 810	920	1, 867	1, 298	1, 908	1, 150	1, 529
	Mean	2, 123	1, 220	1, 795	956	1, 785	1, 394	1, 901	1, 190	1, 546
Mean		1, 976	1, 245	1, 607	1, 107	1, 626	1, 395	1, 737	1, 249	1, 493
Roots cured:										
Nonheated storage	Low	1, 571	1, 505	1, 615	1, 142	1, 361	1, 473	1, 515	1, 373	1, 444
	High	1, 857	1, 446	2, 022	1, 438	1, 325	1, 313	1, 734	1, 399	1, 567
	Mean	1, 714	1, 475	1, 818	1, 290	1, 343	1, 393	1, 625	1, 386	1, 506
Heated storage	Low	2, 395	1, 309	2, 264	1, 057	2, 027	1, 348	2, 229	1, 238	1, 733
	High	2, 165	1, 236	1, 857	990	1, 806	1, 391	1, 943	1, 206	1, 574
	Mean	2, 280	1, 272	2, 060	1, 023	1, 916	1, 369	2, 086	1, 222	1, 654

Mean		1, 997	1, 374	1, 939	1, 157	1, 630	1, 381	1, 855	1, 304	1, 580
Means:										
Low nitrogen		1, 999	1, 341	1, 792	1, 116	1, 605	1, 376	1, 798	1, 278	1, 538
High nitrogen		1, 974	1, 278	1, 755	1, 147	1, 651	1, 400	1, 793	1, 275	1, 534
Nonheated storage		1, 771	1, 372	1, 619	1, 274	1, 405	1, 394	1, 598	1, 347	1, 473
Heated storage		2, 201	1, 246	1, 927	989	1, 850	1, 381	1, 993	1, 206	1, 600
All treatments		1, 986	1, 310	1, 773	1, 132	1, 628	1, 388	1, 795	1, 277	1, 536
All treatments, 2 varieties		1, 648		1, 452		1, 508		1, 536		

[1] Least significant difference between—

	5-percent level (number)
Single values other than means	401
Means of 2 single values that are not means themselves	267
Means of 3 single values that are not means themselves	213
Means of 4 single values that are not means themselves	183
Means of 6 single values that are not means themselves	148
Means of 8 single values that are not means themselves	127
Means of single storage conditions	105
Means of harvests	91
Means of nitrogen levels, of curings, of storage heats, or of varieties	73

TABLE 5.—*Analysis of variance of data contributing to table 4*

Source of variation	Degrees of freedom	Variance
Years	2	20, 976, 636**
Error$_1$	9	455, 586
Varieties	1	38, 844, 056**
Varieties × years	2	4, 171, 751
Error$_2$	9	1, 457, 605
Harvests	2	2, 440, 833**
Harvests × years	4	304, 450
Harvests × varieties	2	2, 326, 578**
Harvests × years × varieties	4	1, 060, 324**
Storages	3	1, 158, 837**
Storages × years	6	739, 238**
Storages × varieties	3	3, 594, 811**
Storages × years × varieties	6	1, 382, 940**
Nitrogens	1	2, 025
Nitrogens × years	2	375, 234
Nitrogens × varieties	1	256
Nitrogens × years × varieties	2	198, 982
Harvests × storages	6	191, 889
Harvests × nitrogens	2	76, 140
Storages × nitrogens	3	533, 845*
Harvests × storages × varieties	6	441, 738*
Harvests × nitrogens × varieties	2	539, 351
Storages × nitrogens × varieties	3	337, 160
Harvests × storages × nitrogens	6	456, 701*
Harvests × storages × years	12	806, 011**
Harvests × nitrogens × years	4	675, 177**
Storages × nitrogens × years	6	325, 566
Error$_3$	414	198, 882
Total	575	-------------

*Significant at levels exceeding 5-percent point.
**Significant at levels exceeding 1-percent point.

EFFECT OF NITROGEN SUPPLY

Two complete fertilizer mixtures, one high in readily available nitrogen and the other low, were used in growing each crop; the plant production of the fleshy roots grown at these nitrogen levels was compared the following spring. The quantities of nitrogen applied per acre per year are shown in table 1.

In Mississippi, in each of the 3 years, the mixtures were all put under the rows on the same day the ridges were made; in South Carolina half was put under the ridge and half applied as a top dressing when the vines began to run.

The results show that there was no simple, over-all effect of the two nitrogen levels used in the production of bedding stock on the plant production of these roots when they were bedded. In fact, the means of the plants produced at the high and low nitrogen levels are prac-

TABLE 6.—*Relation of temperature*[1] *before harvest of Porto Rico sweetpotato roots to plant production the following spring*

Place roots grown and harvest date	Temperature during indicated period before harvest				Mean plants
	30 days		15 days		
	Mean minimum	Mean mean	Mean minimum	Mean mean	
1941					
Blackville, S. C.:	*° F.*	*° F.*	*° F.*	*° F.*	*Number*
Sept. 3	70. 1	80. 9	70. 1	80. 2	1, 981
Oct. 10	67. 5	76. 1	66. 8	77. 9	1, 521
Oct. 31	59. 6	71. 6	58. 3	69. 3	1, 286
1942					
Sept. 2	65. 4	77. 2	76. 1	81. 5	2, 350
Oct. 12	57. 6	72. 2	51. 3	65. 8	2, 002
Oct. 31	51. 6	66. 8	50. 2	65. 9	1, 639
1941					
State College, Miss.:					
Oct. 13	62. 6	74. 3	63. 2	74. 5	1, 366
Nov. 8	52. 9	63. 9	47. 1	57. 3	1, 407
Dec. 1	39. 8	51. 9	41. 7	53. 2	1, 134
1942					
Sept. 17	67. 6	78. 1	67. 7	79. 2	2, 482
Oct. 19	52. 8	67. 2	53. 5	68. 6	2, 296
Nov. 14	48. 9	61. 8	46. 8	59. 7	2, 002
1943					
Sept. 10	69. 2	81. 5	69. 1	80. 4	2, 111
Oct. 23	51. 6	65. 1	47. 7	62. 4	1, 617
Nov. 15	43. 1	56. 0	40. 5	53. 0	1, 749

[1] Calculated from data published by U. S. Weather Bureau. See Climatological Data for the United States by Sections.

tically and statistically identical. This lack of over-all effect was consistent from year to year for both varieties in both places.

Despite lack of over-all effect of nitrogen, there was a small but definite effect within the different storage lots in the Mississippi tests. Table 4 shows that roots from the high-nitrogen plots generally were more productve than those from the low-nitrogen ones when they had been stored without any heat. This was true for both noncured and cured roots, but the effect was greater for those cured. On the other hand, just the opposite was true for roots from heated storage. Furthermore, these effects appear to be influenced significantly by variety (see last 3 columns, table 4). However, no great importance can be attached at this time to this last observation because of the meagerness of the information about nitrogen effects. At the same time, these results recall the rather unusual response, increase in yield, which the sweetpotato shows to nitrogen in the district of Mississippi where these roots were grown. The differences between the high and low levels applied in the Mississippi tests were much greater, too, than in the South Carolina plots.

Effect of Curing and Storing

In the South Carolina tests the roots from the four curing and storage treatments were so arranged in the plant bed that only relatively large differences could be observed with confidence that they were due to treatment instead of random variation. Thus, although cured roots tended to be more productive than noncured and those from heated storage more productive than those from nonheated, the differences were generally small and not significant (tables 2 and 3). The Mississippi tests, however, showed the same tendencies to a greater and highly significant degree (tables 4 and 5). The mean production of all lots cured was significantly, although only slightly, above that of noncured roots. The superiority of the heated storage lots over the nonheated was substantial.

At both locations the most striking differences occurred with the Porto Rico variety and within the late-harvested lots. Although the over-all effects of storage treatment were nonsignificant in the South Carolina tests, the warm-storage lot of late-harvested noncured Porto Rico roots was significantly more productive than the lot stored without heat, producing nearly 700, or 65 percent, more sprouts. For each of the 3 harvests of the same variety in the Mississippi tests there was a superiority of over 300 plants, amounting to as much as 25 percent. Among the cured roots, those stored warm were also superior, but the differences were less striking than among noncured roots. In both locations the Triumph variety was surprisingly unresponsive to the difference in storage temperature. Table 3 shows that the interaction harvests × storages was highly significant in the South Carolina study; in the Mississippi study the interactions storages × varieties and harvests × storages × varieties were significant (table 5).

These particular effects of the curing and storage conditions on sprout production should not be confused with the effects on storage loss. These propagation studies were conducted with sound roots that survived the several storage conditions. The benefits mentioned herein are in addition to the prevention of actual loss of bedding stock in storage.

In Mississippi responses to storage varied significantly from year to year, as might be expected from weather differences to which the roots were exposed. The interaction years × storages × harvests was also significant. The interaction storages × nitrogens has already been mentioned (p. 13).

These studies indicate that in the warmer parts of the South artificial curing is considerably less effective than the proper maintenance of storage temperature alone in retaining high sprout-producing capacity of the Porto Rico variety. Even so, properly cured and stored roots of Porto Rico from early harvest produced about 50 percent more plants than noncured, shed-stored roots from late harvest. None of the treatments, however, were successful in producing consistent and significant improvement in the normally low-propagating capacity of Triumph.

DISCUSSION

It should be kept in mind that these results were obtained in the coastal plain section of South Carolina and in mid-Mississippi, where the autumn and winter temperatures are relatively mild and the temperatures are high enough during the earliest harvests that a fair degree of "natural curing" can proceed without any artificial heat. In more northerly sweetpotato districts, such as those in Virginia, Maryland, or Kansas, a more marked benefit from artificial curing might be expected; in these States nonheated storage of course is entirely out of the question. The particular treatments used in these studies were intended to apply only in comparing practices in use in the warmer parts of the country. The problem largely was to determine whether artificial heat for handling seed stock is profitable in those parts of the South where little or no heat may be needed in most years in order to carry the roots through until bedding time with little actual loss in storage.

Although the bedding stock was grown and the plants were bedded under distinctly different conditions at the two cooperating stations and although conditions varied from year to year at each place there was a recognizable similarity in response to time of harvest and to storage conditions and between varieties throughout these studies.

The much greater difference in nitrogen levels used in Mississippi than in South Carolina may be expected to account, at least in part, for the interaction effects of nitrogen in Mississippi and the complete lack of response in South Carolina.

The three harvests were much closer to the same dates in successive years in South Carolina than in Mississippi, but the more marked responses to time of harvest were noted in South Carolina. The responses to time of harvest were also more consistent in South Carolina, probably because the harvest dates were more consistent in relation to the condition of the crop and to the weather each year.

Although the bedding medium has been shown by Edmond and Dunkelberg (*5*) to affect plant production, the different materials used at the two locations in these studies did not appear to affect the responses of the roots to the several factors involved.

In observing the results of a study of many factors such as this one, it is important that emphasis be placed on the particular combination of factors that gives the best, or poorest, results. Although single factors may each produce relatively small differences "across the board," there may be interaction effects in certain treatment combinations that are enormously significant. Practical recommendations are based on the combination that appears best rather than considerations of single effects. Therefore this study leads to the conclusion that for propagation purposes sweetpotatoes should be: (1) Harvested early, well before frost; (2) stored where they can be protected from temperatures below 50° F.; (3) preferably cured before storing; and (4) harvested from fields receiving small to medium rather than high applications of available nitrogen.

This combination of factors resulted in 50 to 100 percent more Porto Rico plants than were obtained from late-harvested, noncured roots stored without heat. Although the Triumph variety was far less responsive to this set of conditions than was the Porto Rico, no other set of conditions was significantly better. Triumph roots seem able to stand more rigorous temperature conditions than Porto Rico, but results with Triumph should not be applied to other varieties. Triumph is grown to only a small extent; therefore results obtained with it are believed to have only limited application.

SUMMARY AND CONCLUSIONS

Cooperative studies of the effects of two levels of readily available nitrogen, three times of harvest, and four curing and storage conditions on subsequent plant production of bedded roots of Unit I Porto Rico (Porto Rico) and Triumph sweetpotatoes were conducted in Mississippi from 1941 to 1944 and in South Carolina from 1941 to 1943.

At both places the Porto Rico variety produced a significantly greater number of plants than the Triumph. Although the roots of these varieties for bedding were grown under two nitrogen levels, harvested at three different times, and stored under a wide variation of temperature and humidity, the higher plant-producing capacity of the Porto Rico was found to prevail.

Only a great difference in level of nitrogen used in growing the bedding stock had any effect on production of plants from the roots when subsequently bedded, and the few differences were small.

Roots harvested during the early part of the harvesting season usually produced a considerably greater number of plants per bushel than those harvested during either the middle or the late part. In three of the four comparisons of harvest means the roots of the second or third harvest produced significantly fewer plants per bushel than those of the immediately preceding harvest.

In South Carolina and Mississippi storage of roots under favorable conditions of temperature and humidity seems to be more necessary for high plant production than artificial curing of the roots alone. The differences in plant production between roots from heated and nonheated storages were greater than those between artificial curing and no artificial curing. These effects are in addition to reduction of actual losses of bedding stock by use of proper curing and storage conditions.

PRACTICAL RECOMMENDATIONS

Even in the warmer parts of the South, where sweetpotatoes can be kept with fair success from harvest to bedding time with little or no artificial heat, special attention to time of harvesting, to curing, and to storage temperatures will greatly increase the yield of plants per bushel of Porto Rico bedding stock.

For propagation purposes roots should be harvested at the very beginning of the normal harvest range of the district or section. Early-harvested roots usually produce more plants than those harvested about the middle or last of the harvest season.

In the warmer parts of the South, where natural temperatures are relatively high, reaching 80° F. or more at the beginning of the harvest season, there is little if any significant benefit from a short (5-day), artificial-heat curing treatment upon subsequent sprout production. Sweetpotatoes harvested early under these conditions may be safely put into the storage house without applying artificial heat at once, provided natural temperatures approach those recommended for curing. At midharvest season or later, however, conventional curing conditions should be used. In the cooler sweetpotato-growing districts curing is believed essential regardless of the time of beginning the usual harvest.

Provision should be made for heating all sweetpotato storage structures to prevent the temperature falling below 50° F. at any time. Chilling during the storage period is shown to lower the plant-producing capacity of Porto Rico roots very seriously. Even in the warmer parts of the South this protection should be provided if the best results are to be obtained in the plant bed.

Although nitrogen supply in the field appears to have but little effect on sprout-producing capacity, it is recommended that in growing bedding stock nitrogen fertilization be kept to the lowest level consistent with good yields. Excesses should be definitely avoided.

The Triumph variety, when grown in the lower South, appears more tolerant to somewhat adverse storage conditions than the Porto Rico, but it consistently produces fewer plants per bushel.

In these studies the greater plant production of the best handled roots as compared with that of the poorest represented a saving of 4 to 5 bushels of seed stock[4] and therefore a saving of bed space and costs in growing the plants required to set an acre in the field.

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[4] Calculated on the basis of 10,000 plants per acre, 15 inches by 3½ feet.

U. S. GOVERNMENT PRINTING OFFICE: 1948

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